Control of a display

FIELD OF THE INVENTION

The present invention relates to the control of a display, and more particularly to contrast and brightness control of a display.

BACKGROUND OF THE INVENTION

Today, many different types of displays exist. When looking at a display sometimes a user wants to adjust brightness and/or other settings of the display to get a better picture. Sometimes it is possible to change the environment instead, for instance to create a dimmed environment. Often a combination of adjusted settings and environmental conditions is used. Typical parameters that can be changed in the display are contrast and brightness. In common (digital) display systems, contrast and brightness can be regulated in the video stream before gamma compensation has been performed. This can be represented by a formula, which includes gamma:

$$L_{out}=\{B + C*(Video_{in}/2^n-1)\}^y \quad \text{(I)}$$

where

$Video_{in}$ = digital video input signal

L_{out} = Luminance, light from display

B = Brightness offset ($0 < B < 1$, typical default B=0)

C = Contrast factor ($0 < C$, typical default C=1)

n = Resolution (number of bits, typical default n=8)

y = Gamma value ($1 < y < 3$, typical default y=2.4)

In a Plasma Display Panel, (PDP), a control unit can be used for controlling the consumed electric power of a display, for instance so that a brightness level is forcibly lowered to suppress consumption of power below a predetermined level. An Automatic Power Control (APC) unit avoids overloading the PDP (the panel and the power-supply of the PDP). In a conventional APC unit, typically the consumption of electric power is detected by detecting a mean current flowing through a high voltage power source that drives the

PDP. Typically, the detected current value is compared to a reference value and periodically the APC unit modifies signals driving the PDP.

US-A-5 956 014 describes an analog brightness value set by a variable resistor ιat is converted into a digital brightness value.

When the APC unit is limiting the luminance of the PDP, contrast and brightness settings in the video stream will not have a predictable effect, while the APC unit will regulate to a new setting. This implies that optimal display performance cannot be obtained.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method and apparatus for a display by which contrast and brightness control is improved. The invention is defined by the independent claims. The dependent claims define advantageous embodiments.

Preferably, the object is realized by implementing contrast and brightness control independent from the video processing, close to the display. Preferably, contrast and brightness are implemented in an existing power control unit, typically an APC unit that controls luminance of the display panel, typically a PDP. This provides optimal display performance with only little extra hardware cost. Furthermore, digital video processing is not affected since the unit is separated from the video processing. Advantageously, contrast and brightness regulations are performed in the APC unit by varying the number of sustain pulses per second. In this way, new settings will have a predictable effect.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood from the following description of the preferred embodiments of the invention read in conjunction with the attached drawings, in which:

Fig. 1 illustrates a PDP generating light;

Fig. 2 illustrates a PDP reflecting light;

Fig. 3 illustrates a PDP generating and reflecting light;

Fig. 4 illustrates a PDP generating, reflecting light and ambient light; and

Fig. 5 illustrates the configuration of an AC-driven plasma display apparatus according to a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

A PDP device, plasma display controller and plasma display driving method ccording to various embodiments of the present invention will now be described in detail with reference to the accompanying drawing figures.

In the following, a PDP device will be described; however it should be noted that this is only an example of a display type. Other types of displays typically other sub-field driven displays, for instance liquid crystal displays (LCDs) etc are also within the scope of the invention as set out in the claims.

A user is often equipped with a set of controls to adjust a display to a specific environment or to adjust video processing to personal preferences. In some displays, an automated process, driven by data from sensors might take care of the adjustment of the display for specific environmental conditions. Other displays will require the user to give feedback via the user controls. However, besides these adjustments, a user may like to change some settings to match with personal preferences, examples are for instance: color saturation, more contrast at specific gray-levels (for instance to see the back-ground of a horror-scene), histogram control or color-point (to get a warm or cool impression of an image). These are typical video processing features not correlated to environmental conditions.

The image quality of a PDP device depends on parameters such as: black-level, contrast ratio (dark room/dim surround/daylight), dynamic peak white (small area and short time), average peak white (large area and continuous), white point (e. g. D65), number of displayable gray-levels, and dithering. Contrast and brightness control are user settings, influencing the luminance and contrast ratio. This will be described below with reference to accompanying Figs. 1-4.

In Fig. 1 it is illustrated a PDP 1 generating light (illustrated by arrows going out from the PDP). The contrast ratio (CR) follows the formula:

$$CR = L_{max}/L_{min} \qquad (II)$$

where L_{min} = minimum Luminance (light), and L_{max} = maximum Luminance (light).

In Fig. 2, the PDP reflects incident light (L_{in}) as reflected light (L_{ref}). The reflection ratio (r) can be represented in a formula:

$$r = L_{ref}/L_{in} < 1 \qquad (III)$$

In Fig. 3 the PDP generating and reflecting light is illustrated, whereby CR can be represented by a formula :

$$CR = n*(L_{max} + n*r*L_{in})/n*(L_{min} + n*r*L_{in}) \quad (IV)$$

where n = filter plate transparency < 1.

If, as illustrated in Fig. 4, a PDP also is under the influence of ambient light (L_{amb}), CR can be represented by a formula as follows:

$$CR = \{n*(L_{max} + n*r*L_{in}) + x*(L_{amb})\} / \{n*(L_{min}\ n*r*L_{in}) + x*(L_{amb})\} \quad (V)$$

where x = part of ambient light which affects the perception ($0 < x < 1$).

The formulas (III) - (V) show that L_{in} and L_{amb} reduce the theoretical CR. Moreover, they also show that L_{min} should be kept as small as possible (generate less light during address and erase phase). L_{ref} can be reduced by reducing n in front of the panel, but this also reduces $L' = n*L_{max}$. L_{in} and L_{amb} can be reduced by operating in a dimmed environment, i. e. closed curtains for instance.

A method of controlling a display panel according to a preferred embodiment of the invention will now be discussed. The method comprises the step of providing manual contrast and/or brightness control by controlling the luminance of the display panel.

This will be further described in the next formulas, which compare the effects of contrast and brightness regulation with processing in the video versus processing in the luminance domain:

$$L_{out} = \{B + C*(Video_{in}/2^n-1)\}^y = B' + C'*(Video_{in}/2^n-1)^y$$

Assuming y=2 and $B' = B^2$, $C' = C^2$, the formula becomes:

$$L_{out} = \{B + C*(Video_{in}/2^n-1)\}^2 = B^2 + C^2*(Video_{in}/2^n-1)^2$$

$$L_{out} = B^2 + 2BC*(Video_{in}/2^n-1) + C^2*(Video_{in}/2^n-1)^2 = B^2 + C^2*(Video_{in}/2^n-1)^2$$

$$L_{dif} = 2BC*(Video_{in}/2^n-1)$$

When the brightness control B=0, the luminance difference $L_{dif} = 0$.

It can be proven that when B=0 it does not matter whether contrast processing is done in video or luminance domain.

Preferably, the luminance of the display panel is controlled according to the formula:

$\text{Video}_{out} = (2^n\text{-}1) * \{B + C^*(\text{Video}_{in}/2^n\text{-}1)\}$

'here

Video_{in} = digital video input signal

L_{out} = Luminance, light from display

B = Brightness offset

C = Contrast factor

n = Resolution

y = Gamma value

or in an existing gamma correction unit, according to the formula:

$L_{out}=\{B + C^*(\text{Video}_{in}/2^n\text{-}1)\}^y$

The control can also provided according to an alternative formula:

$L_{out} = \{B + C^*(\text{Video}_{in}/2^n\text{-}1) - (D^* |(\text{Video}_{in}/2^n\text{-}1)\text{-} E | \}^y$

An embodiment of the invention will now be described, with reference to Fig. 5, in which it is illustrated how contrast/brightness control is provided in an automatic power control (APC) unit. Fig. 5 is a block diagram illustrating a preferred embodiment of a display system 10, according to another embodiment of the invention. The display system 10 comprises a PDP 1 having display cells arranged in a X-Y orthogonal matrix, a processor unit 2, a contrast/brightness controller 3 and an automatic power control unit 4.

The PDP 1 is of conventional type and will therefore not be described in more detail since PDPs are well known. The contrast/brightness controller 3 is connected to the automatic power control unit 4, or can be a part of the same. Also software-only solutions are possible, provided that the contrast/brightness controller 3 is adjacent to or part of the power control unit 4.

In an AC-type PDP device, the data to be displayed is written for every line, and then the PDP is maintained by sustain discharges. The brightness of the PDP varies in proportion to the number of sustain discharges per time interval, and hence the brightness can be changed by the number of sustain discharges.

The automatic power control unit 4 modulates the consumed power of a display, in this embodiment the PDP 1. The generated light is regulated by changing the number of sustain pulses per second to the PDP. After image load of a frame has been

determined, the light generated by the image can be amplified or attenuated, save guarding the PDP.

In a conventional PDP device, in case the APC unit is attenuating the image to educe the power consumption or temperature, the luminance of the image is reduced. In this case, a user might try to change contrast/brightness settings to increase the luminance. When amplifying the video-data, the APC unit would immediately attenuate the image representation, back to the initial level but at reduced quality. This can be avoided by providing the contrast/brightness settings to the automatic power control unit according to the invention as implemented in the embodiment shown in Fig. 5.

Preferably, according to another preferred embodiment of the invention, the controller 3 can be arranged to provide for a user to set parameters to satisfy the user.

In this way, the digital video processing is not affected by the user-controllable contrast and brightness settings, since the settings are implemented after the processing has been performed in the processor 2. Therefore, it is possible to exploit the full available dynamic range for video data processing.

According to another preferred embodiment of the invention, the contrast and brightness of the PDP are set by increasing or decreasing the number of sustain pulses (per time period) to a given sub-field of the PDP 1 in accordance with the given values. This is a very accurate control mechanism, which gives an optimal and predictable adjustment.

An offset in the video-level due to brightness control according to formula

$$L_{out}=\{B + C^*(Video_{in}/2^n-1)\}^y \qquad (I)$$

will generate a small color saturation artifact with respect to original image. This is not important when the brightness is adjusted to the black level of the display. Driving sustain pulses to a fully addressed display gives the effect of a classic brightness control. This can be achieved by addressing all lines at once instead of one-by-one, saving time.

For PDP, the brightness is typically set to “0”, while a minimum luminance pixel is already clearly visible.

Amplifying the sustain level of sub-fields (C) resembles the effect of a contrast regulation. It can be noted that these variations are performed in the luminance domain instead of the video domain, however this has no impact.

Since the contrast/brightness controller 3 is implemented in the automatic power control unit 4, preferably in a timing and control unit of the same (not shown), it can provide an optimal display performance, driven by software, with only little extra hardware cost.

When contrast and brightness control is done in the timing and control process, various timing aspects can be included. Temporary driving the display above the recommended automatic power control level can provide a better match with the user's demands.

Often a display supports a limited number of gray-levels, combined with dithering. When user-control and APC regulate the video level, for each pixel a course stepwise variation of the video level is calculated. The dynamic range of the video data must allow increasing video levels. In case of a user-control and APC regulating the sustain-level, variations on the sustain level step-size will cause variations of image representation at a more accurate resolution. In this case the video processing chain is independent of binary distributed sub-field weights. For example: the video levels

1	2	4	8	16	32	64	128

result in e.g. the following sustain levels for respective successive sub-fields:

4	8	16	32	64	128	256	512.

25 % reduction implies the following sustain levels for respective successive sub-fields:

3	6	12	24	48	96	192	384.

10 % reduction implies the following sustain levels:

3.6	7.2	14.4	28.8	57.6	115.2	230.4	460.8.

Broken sustain levels can be realized by means of temporal sustain dithering.

The invention can be realized by controlling contrast and brightness in a display panel by means of either an automatic power control unit, already controlling luminance of the display panel by varying a number of sustain pulses per second, or a timing and control unit, controlled by software process which is already controlling luminance of the display panel by varying a number of sustain pulses per second. Brightness can also be controlled in dependence on a user brightness control signal by controlled light generation during an erase phase of a display panel, by suitably adjusting the shape and/or number of erase pulses generated by the timing and control unit.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed

in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In e device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.